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MANAGING CAPITAL EXPENDITURES : APPRAISAL OF SPECIFIC PROPOSALS *

By

Gordon Shillinglaw
Massachusetts Institute of Technology

The principal objective of capital expenditure management is to protect the investor's equity in the firm. Protection, however, is much more than a mere maintaining of the status quo. Rather, capital management protects by seeking to achieve the most favorable future profit position in relation to investment by selecting the best among investment alternatives currently available. In order to meet this objective, capital management must deal with the twin problems of directing the firm's investable funds into investments of the greatest long-range potential profitability and of adjusting the amount of funds to the opportunities available. The purpose of this paper is to sketch briefly some of the methods that have been developed to solve these problems.

THE IMPORTANCE OF SOUND CAPITAL MANAGEMENT

Capital management problems differ from other problems of alternative choice because of the importance of the time element in estimating the profitability of investment outlays. The essence of a capital outlay is that it can be justified only by its results in a number of time periods after the outlay is made. The conventional definition of the length of a single time period in this context is one year, and this definition can be accepted for analytical purposes without serious argument. By this definition,

* This article is a revision of a presentation at the 66th Annual Meeting of the ASEE, Berkeley, California, June 1958.

then, an investment decision can be distinguished from other types of financial decisions by the fact that it must be based explicitly on a forecast of performance in periods longer than one year.

This definition is obviously not sharply delineated. Decisions relating to product mix, pricing, or distribution methods also have effects that linger beyond a year. An ill-advised product emphasis decision may have cumulative effects and may start a downtrend whose momentum is difficult to halt, but the decisions themselves can generally be based on forecasts of conditions and effects during a relatively short planning period, a year or less. Investment decisions, on the other hand, can seldom be based on conditions forecast for the coming year alone, because this is too short a period for recovery of investment outlays and a return of an adequate profit.

In this sense, capital decisions are not reversible. They shape the physical structure of the firm's profit-making capacity for a substantial period to come. If the decisions turn out to have been wrong, the loss per dollar of outlay is likely to be several times as great as the loss resulting from a poorly-designed advertising program or misplaced sales emphasis. Management can extricate itself from an unfavorable situation brought on by an unwise capital expenditure only by writing off the sunk cost and selecting the alternative that will produce the greatest profit starting from there. Meanwhile, the funds sunk in the facilities are no longer in liquid form and are unavailable for investment in other alternatives that might produce greater profits. These investment errors cannot be avoided under conditions of uncertainty,

but better planning and better control techniques can reduce their frequency.

COMPONENTS OF A CAPITAL MANAGEMENT PROGRAM

Control of a company's capital outlays is a function of top management, although the system may be designed in such a way as to delegate portions of this responsibility to lower levels within the organization. By way of introduction to the main topic of this paper, the appraisal of specific investment proposals, it may be helpful to sketch briefly several aspects of a controls system designed to meet top management's objectives, namely:

1. Positive search for profitable investment opportunities.
2. Long-range capital planning.
3. Short-range capital budgets.
4. Screening of individual proposals.
5. Post-completion review of project performance.
6. Disposal of obsolete facilities.[1]

Although most companies find it necessary to reject some of the investment proposals that are presented each year, very few firms suffer from an excess of proposals whose profitability is considerably greater than the company's minimum profit requirements. The capital controls program therefore should be designed to stimulate the search for investment opportunities in the

[1] For a more complete discussion of the interrelationships among different aspects of the capital controls program see Joel Dean, "Controls for Capital Expenditures", in American Management Association Financial Management Series 105, Modern Management of Capital Expenditures. American Management Association, New York, 1953.

knowledge that some of these projects will probably prove highly profitable. In this, as in all phases of the capital controls program, the influence of potential profitability should be kept uppermost in mind. Other objectives, such as maintaining product quality or market share, are valid only insofar as they spell out in greater detail the profit criterion.

Long-range capital plans serve two general purposes. First, they provide the framework for the analysis of current investment proposals. How well a proposed investment fits into the company's long-range development plan may be an important determinant of its profitability. To be used in this way, however, the long-range plan itself must embody the concept of profitability. That is, the effects of the plan on company profits must be considered explicitly when the plan is being drawn up. Otherwise the plan provides no valid bench mark to assist in evaluating the profitability of specific proposals that might either implement or interfere with the long-term picture. The second use of long-range plans is in the shaping of the company's financing program. A sound capital plan will permit the company to anticipate its needs for funds farther in advance and in a more orderly manner and will permit it to meet these needs in the most economical fashion, giving adequate consideration to the available alternatives.

The annual capital budget is ordinarily the first year of the long-range plan, but is generally much more detailed and closer to an actual commitment to the stated plan of investment. Projects that are included in the annual budget are highly likely to win approval and the underlying profitability justification for major

projects at least should be given concrete form at the time the budget is drawn up. The one year budget also provides a means of adjusting capital outlays to the funds currently available, or vice versa, and this point is discussed further below.

The focus of the capital controls program is the system for screening individual investment proposals to select those that will actually be approved for the expenditure of company funds. The mere fact that a project is listed in the annual capital budget does not constitute an authorization for expenditure, even though this approval is likely to be granted. Specific approval must be based on the latest and most complete information available at the time the decision is made and analysis of this information may point in a different direction from that indicated at the time the budget was prepared. Project screening requires the solution of at least three types of problems - selection of a standard of minimum acceptable profitability, measurement of the profitability of individual proposals, and the development of forms and approval routines to implement company policies. The major part of this paper is devoted to a discussion of the first two of these problems.

Once a project is accepted and is put in operation, it is desirable to review its performance by comparison of actual results with those estimated in the project justification. The purposes of this post-completion review are to provide checks on the accuracy of the estimates and to identify probable trouble spots that arise because performance is less favorable than the estimates. For this purpose, review of all major projects and a sample of smaller

projects should be sufficient.

The final stage in the life of an investment is its eventual disposal. By this time the nature of the review is changed. It no longer matters whether the facilities were all acquired as part of a single project or were developed piecemeal over an extended period of time. What matters is that a given package of assets is no longer sufficiently profitable to justify retention. The analysis of problems of this kind is similar in concept to the analysis of individual proposals for new investment and will be discussed briefly in that connection later on.

THEORY OF CAPITAL RATIONING

The classic solution to the capital rationing problem can be stated in conventional terms. All of the projects in which the firm might invest constitute the demand for funds. Each project has a maximum price that it can afford to pay for funds, represented by the profitability promised by that project. When these projects are arrayed in descending order of profitability, they constitute a demand schedule for investment funds.

On the supply side, funds are available from a number of sources. Each of these sources, or, more strictly, each dollar of capital supply, has a minimum price beneath which it will not be made available, and this is represented by the interest rate. When capital funds available are arrayed in increasing order of interest charges, they constitute a supply schedule of investment funds. The point at which these two schedules meet specifies the amount of capital that this firm should employ, the sources from which it should be secured, and the projects in which it should invest.

Unfortunately, this model is much too unreal for practical application. A demand schedule can, and should, be prepared along the lines suggested in the model, but this schedule is unavoidably subject to two kinds of errors, both stemming from the fact that the demand schedule must refer to funds that might be spent during a period of several months and perhaps a year in advance. This means, first, that the demand schedule must be based on individual project estimates of outlay requirements and expected profitability that are subject to revision before the projects actually come up for review, and second, that it is not always possible to foresee all of the investment proposals that will be presented during the year. Thus even if the supply schedule could be derived with certainty, the uncertainty surrounding the demand schedule would cause the point of intersection to be replaced by a zone of intersection, similar to that suggested in Figure 1.

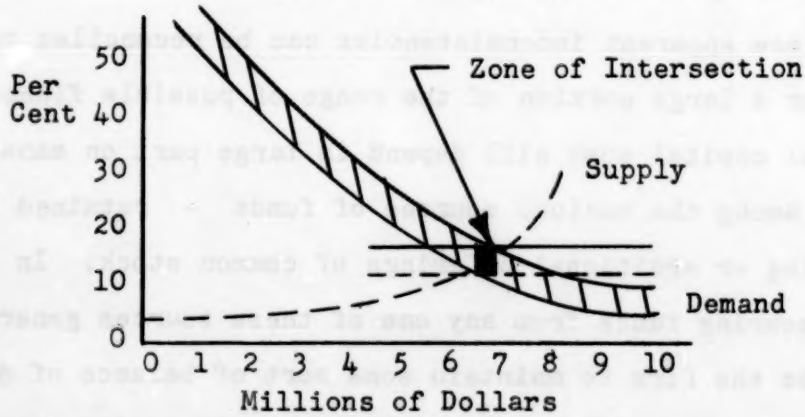

Figure 1

On the supply side, the model is even more unrealistic. According to the model, the amount of funds supplied to a firm will be smaller at lower rates of interest than at higher capital costs

and the firm will secure funds first from the lowest cost sources and move gradually upward in the cost chain. In some instances, this model appears at first glance to conform to fact. The firm that has utilized most of the conventional sources of funds will face rising capital costs as it moves into sale-leasebacks, installment financing and factoring. The firm that has financed heavily in the past by means of debt will find it necessary to move into higher cost equity funds for any increments of capital.

Unfortunately, this apparent confirmation of the model stems not from a universal law but from the particular circumstances under which this behavior is observed. It is also possible to observe the reverse situation, in which a company with a strong earnings position and no previous debt position now decides to obtain additional funds through borrowing. In this case the supply schedule could be pictured as one that slopes downward to the right instead of upward as shown in Figure 1.

These apparent inconsistencies can be reconciled by observing that for a large portion of the range of possible financing the marginal capital cost will depend in large part on management's choice among the various sources of funds - retained earnings, borrowing or additional offerings of common stock. In the long-run, securing funds from any one of these sources generally requires the firm to maintain some sort of balance of debt and equity and, in point of fact, the high cost equity money must be secured first in order to tap lower cost debt sources.

The implications of this reasoning are not entirely clear to all students of the capital rationing problem, but most companies

will probably find it desirable to assume some stable long-run balance of funds from various sources and assume that the interest cost of funds from each source will not be affected by the firm's use of these funds as long as the capital structure maintains the balanced pattern. On this assumption, the minimum rate of return that can be applied to investment projects can be determined by weighting the capital costs of the various sources in proportion to their respective roles in the company's long-range financing plan. The average cost of capital computed in this manner can then be used as an approximation to the minimum rate of return that any project must promise to justify expenditure of company funds on the grounds that anything less would dilute the company's earnings and impair its ability to secure funds on a balanced basis in the future.

Use of a weighted cost of capital of this sort separates the evaluation of the project from the evaluation of the means of financing it. It is a clear fallacy to judge the acceptability of any specific investment proposal by comparison of its rate of return with the interest cost of the specific funds to be devoted to that project. This would mean that when the company is borrowing money it would be willing to apply a lower earnings requirement to investment proposals than it would use when funds are derived solely from retained earnings or additional stock financing. Or, if specific projects can be tied to specific financing, it would mean that such projects would be subjected to a much lower earnings requirement than projects made at the same time from general company funds. The fact of the matter is that

the selection of any particular source of funds for immediate financing imposes some requirement for later financing from another source if the long-run balance is to be maintained. If the balance is to be altered permanently, the solution is to revise the average cost of capital rather than create distortions in the profitability pattern of various parts of the firm's asset structure.

The measurement of the cost of each of the major components of the firm's balanced capital structure is subject to serious empirical difficulties. The cost of capital from any source may be defined loosely as the price that must be paid in order to attract new capital to the company for investment purposes.[2] In order to borrow, for example, the company must promise the bondholders a series of specified interest payments plus repayment of the face value of the bonds at some future date. The relationship between the net proceeds of the bond sale and the after-tax stream of future payments to the bondholder determines the effective yield of the bonds from the borrower's point of view and this is the specific cost of borrowed funds.

The specific cost of equity capital is more difficult to compute because there are no contractual obligations for the company to pay any specified sums at any specified times to purchasers of

[2] For more complete discussion of cost of capital, see Ezra Solomon, "Measuring a Company's Cost of Capital", The Journal of Business of the University of Chicago, Vol. XXVIII, No. 4, October 1955, pp. 240-252; and Roland P. Soule, "Trends in the Cost of Capital", Harvard Business Review, Vol. XXXI, No. 2, March-April 1953, pp. 33-47.

the company's stock. Nevertheless, potential stockholders will not invest additional funds in a company unless they are convinced that this investment will provide them with dividends and capital gains equal to the return provided by alternative uses of their funds. Measurement of the cost of common stock capital, therefore, has generally reflected an estimate of the relationship between the price of a share and the earnings that a potential purchaser of a share expects to receive in the future. Indications of this relationship are provided by past relationships between per share earnings and market price of the company's stock, adjusted for flotation costs and for probable future growth in per share earnings and/or price.

The cost of retained earnings is calculated in a similar fashion on the grounds that stockholders expect their Board of Directors to retain earnings only to the extent that these earnings can be invested as profitably within the company as the stockholders could invest them externally if they were to be paid out as dividends. A lower rate of return on retained earnings than on new equity capital obtained through public offering of shares might be justified, however, because personal income taxes on dividends reduce the amount of funds available for reinvestment.

The difficulties of measuring the cost of common stock capital are considerable and the resulting estimates are subject to fairly wide ranges of error. Furthermore, the costs of both equity and debt depend in part on capital structure. This does not mean that the attempt should not be made or that the estimates should not be used in internal capital rationing. It

merely means that the estimated cost should be interpreted as an approximation rather than as a precise figure. This concept is illustrated in Figure 2.

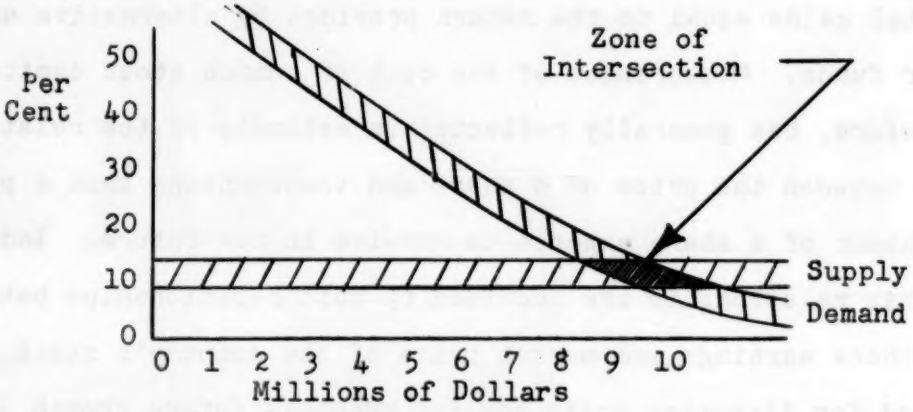

Figure 2

SELECTING THE MEASURE OF PROJECT PROFITABILITY

The preceeding paragraphs have purposely avoided any firm commitment as to the appropriate measure of the profitability of investments in individual projects. To be satisfactory, the measure must reflect adequately the three basic determinants of project profitability, namely, cash outlays associated with the proposal, cash inflows that it is expected to produce, and the periods of time during which these cash flows are expected to take place. It should also permit the development of standards of minimum acceptability based on the company's cost of capital.

Although some companies use no specific measure of project profitability or rely on personal judgment and personal persuasion as a means of rationing available capital funds, many companies have for a considerable period of time used some measure of cash payback period or the ratio of average lifetime net book earnings

to investment outlay. The popularity of these methods has probably been the result of their apparent simplicity, but it can be demonstrated that they fail to meet one or more of the criteria listed in the preceding paragraph.[3] Most authorities today recommend that investment projects be analyzed by some method that embodies the concept of discounting the after-tax cash flows of a project during its expected life.[4] These specifications are met in varying degree in at least three methods of evaluation:

1. Net present value of future cash flows
2. Discounted cash flow rate of return
3. Uniform equivalent annuity

Illustration of Methods

To illustrate these methods it will be helpful to formulate a simple example of a proposal to install additional manufacturing facilities. The initial investment outlay is $1,000,000, all of which is to be capitalized for tax purposes, plus $300,000 investment in working capital. Annual cash earnings are expected to be $100,000 for the first year, rising by $100,000 increments each year for three years to $400,000 annually in the fourth year and

[3] For a discussion of the shortcomings of these methods, see Joel Dean, "Measuring the Productivity of Capital", Harvard Business Review, Vol. XXXII, No. 1, January-February 1954, pp. 120-130, and Ray I. Reul, "Profitability Index for Investments", Harvard Business Review, Vol. XXXV, No. 4, July-August 1957, pp. 116-132.

[4] Joel Dean: Capital Budgeting. Columbia University Press, New York, 1951.
Eugene L. Grant: Principles of Engineering Economy, 3rd edition, The Ronald Press, New York, 1950.
Friederich and Vera Lutz: The Theory of Investment of the Firm. Princeton University Press, Princeton, N.J., 1951.

thereafter and declining in the tenth, eleventh and twelfth years to zero in the thirteenth year. The straight-line depreciation rate for tax purposes is 6% and the tax rate is 50%. Salvage value of physical facilities at the end of the twelfth year is estimated to be negligible, but the working capital investment can be recovered at that time. The company estimates its after-tax cost of capital to be 10%.

The assumption that underlies the use for project evaluation of the method of discounting all future sums to a present value at some rate of interest representing the cost of capital to the firm is that the firm wishes to maximize its present worth. Any outlay that will produce discounted benefits in excess of discounted costs will therefore be worth making, provided only that sufficient capital is available to finance all the projects that have this attribute. The calculation of present value is illustrated in Table 1. In this proposal, the lifetime excess of after-tax cash inflows over cash outflows is estimated to be $1,230,000, but after discounting to allow for the cost of capital tied up during the twelve-year period, the present worth of this project is just slightly higher than zero, or $46,000. This project, therefore, is just above the margin of acceptability.

The second method of evaluating project profitability is to calculate a rate of return on investment by the technique known variously as the investor's method or discounted cash flow method. Under this approach, rate of return is defined as the interest rate at which the algebraic sum of the discounted stream of future cash inflows and cash outflows will be zero. To state this in

TABLE 1

Present Worth of Plant Expansion Proposal
(Dollars in Thousands)

Time Period	Cash Receipts(+) or Outlays(-)	Tax Free Write-off (Depreciation)	Tax at 50%	After-tax Cash Flow	Discount Factor at 10%	Present Worth at 10%
0	- 1,300			- 1,300	1.0000	- 1,300
0-1	+ 100	60	20	+ 80	.9516	+ 76
1-2	+ 200	60	70	+ 130	.8611	+ 112
2-3	+ 300	60	120	+ 180	.7791	+ 138
3-4	+ 400	60	170	+ 230	.7050	+ 161
4-5	+ 400	60	170	+ 230	.6379	+ 147
5-6	+ 400	60	170	+ 230	.5772	+ 133
6-7	+ 400	60	170	+ 230	.5223	+ 120
7-8	+ 400	60	170	+ 230	.4726	+ 109
8-9	+ 400	60	170	+ 230	.4276	+ 98
9-10	+ 300	60	120	+ 180	.3869	+ 70
10-11	+ 200	60	70	+ 130	.3501	+ 46
11-12	+ 100	60	20	+ 80	.3168	+ 25
12	+ 300	280	- 70	+ 370	.3012	+ 111
Total	+ 2,600	1,000	1,370	1,230		+ 46

other terms, this is the maximum rate of interest that can be paid out of the earnings of the project. If the cash flow estimates are correct, at the end of the project's life the company will have broken even on this project if an interest rate equal to the rate of return has been paid on capital employed. In the illustration above, discounting at a 10 per cent interest rate leaves a positive present worth, so the rate of return must be in excess of 10 per cent. Discounting at 11 per cent, however, leaves a negative present worth, and the actual rate of return is 10.65 per cent by interpolation. In this case, the margin in excess of the company's minimum cutoff rate is insignificant and this project must be

* Based on continuous compounding uniform cash flows within individual years.

regarded as borderline.

Still a third variant on these methods is the "equivalent uniform annual cost" method.[5] Under this method, the cost stream associated with each alternative is converted by discounting at a given interest rate into a uniform annual amount. This amount may be described as the annuity equivalent of the stream of cash flows. The alternative which shows the lowest equivalent uniform annual cost is the alternative that should be accepted. In the illustration above, a 12-year annuity of $6,583 per annum is equivalent to the 12-year stream of positive and negative cash flows. Alternatively, the present worth of these cash flows, or $46,000, is also the present worth of a $6,583 annuity for 12 years. This indicates that the company should be slightly better off if this project is accepted than if the zero-annuity alternative is selected.

Terborgh[6] utilizes a variant of the equivalent uniform annual cost method in his work on equipment replacement. The main difference between Terborgh's approach and earlier applications of this method is that he does not take economic life as given, but rather computes a different equivalent uniform annual cost for different time periods for each alternative. He then selects for each alternative the time period which produces the lowest equivalent annual cost, and then compares these figures for the various alternatives under study. The Terborgh method has advantages when

5 Grant, op. cit., pp. 85-105.
6 George Terborgh: Dynamic Equipment Policy. McGraw-Hill Book Company, New York, 1949.

the gradient of technological improvement in future equipment can be predicted with a fair degree of reliability. It also has the advantage of forcing explicit consideration of the factors that determine economic life. The computational routines are more complex than for any of the methods outlined above, however, and it is perhaps subject to a greater danger of misapplication through the adoption of simplifying assumptions, particularly as to technological improvement gradients.

Comparison of Methods

Under many circumstances the application of these three methods will lead to the same conclusions, but the exceptions justify the conclusion that the differences among the methods are worth considering. In making these comparisons, the present value and uniform equivalent annuity methods will be regarded as one method. The equivalent annuity method and its variants have been developed largely in connection with problems in which cost differences are the dominant factor in decision-making. These methods can be adapted, however, to encompass problems in which revenue differences also enter in, by calculating equivalent uniform annual profit for each alternative. The present worth and the uniform annuity methods will yield the same answers as long as the interest rate and cash flow data used are the same. In problems of the type illustrated in Table 1, the equivalent annuity method requires an extra and superfluous calculation, but in some cases it provides a more readily acceptable way of presenting the data. Whenever the problem is to choose among

alternative cost patterns to achieve a specific output goal, the equivalent annuity method reduces to Grant's equivalent uniform annual cost and this is likely to have wider acceptability with operating people than the more abstract present worth figure. Beyond this, the two methods can be regarded as identical.

Lorie and Savage[7] have pointed out three substantive problems for which use of a positive present worth criterion provides a more accurate solution than is provided by the discounted cash flow rate of return. First, there is the possibility that some projects may have more than one rate of return because of peculiarities in the time pattern of cash flows. If this were the only limitation of rate of return, the superiority of present worth would be extremely limited because of the probable rarity of cases of this type. Of more serious concern, however, is the fact that there are situations in which rate of return does not provide an adequate basis for choice among a group of mutually exclusive alternatives. This results from the fact that application of the rate of return method requires a calculation of a separate incremental rate of return for each segment of the investment outlay[8], whereas for many projects the investment outlays under the various competing alternatives do not all occur at the same point in the time stream, which makes it difficult to array the alternatives in

[7] James H. Lorie and Leonard J. Savage: "Three Problems in Rationing Capital", The Journal of Business of the University of Chicago, Vol. XXVIII, No. 4, October 1955, pp. 229-239.

[8] Gordon Shillinglaw: "Measuring the Investment Worth of Capital Proposals", American Management Association Financial Management Series No. 105, op. cit.

order of increasing investment outlay. Some writers have even objected to the rate of return calculation on the ground that it makes implicit assumptions as to the profitability of reinvestment of the funds released through project earnings, but this objection can be overcome by using identical time periods for the calculation of rate of return on all alternatives.[9] In any event, the use of present worth calculations also requires uniform time periods for comparison.

The third situation in which present worth is superior to discounted rate of return arises when there is a temporary shortage of investment funds. In some instances, the capital available will be inadequate to finance all the projects which promise a positive present worth and some means must be found to select the most worthy projects from this group. The most accurate way to do this is to raise the discount rate until enough projects have been eliminated to equate the quantity of funds demanded with the quantity available. Raising the discount rate increases the premium on near-term earnings and therefore may change the relative ranking of some of the projects that promised a positive present worth at the old rate. It will also yield a different ranking of projects in some cases than is provided by rate of return, although this difference is important only in the case of projects that have more than one rate of return, as mentioned above.

[9] Armen A. Alchian: "The Rate of Interest, Fisher's Rate of Return over Costs and Keynes' Internal Rate of Return", American Economic Review, Vol. XLV, No. 5, December 1955, pp. 938-945.
See also Romney Robinson: "Comment" on Alchian's paper, American Economic Review, Vol. XLVI, No. 5, December 1956, pp. 972-973.

It should be apparent that the calculation of rate of return by this method requires more clerical effort than discounting by a given interest rate. Rate of return does, however, have the advantage of familiarity which present worth lacks. In most circumstances the use of rate of return instead of present worth at a given interest rate will not seriously alter the ranking of projects, and the choice between these two methods can be made largely on the basis of clerical convenience and ease of presentation.

SUMMARY

This paper has concentrated on one aspect of capital expenditure management, namely, the appraisal of individual investment proposals and the rationing of available capital among these projects. It has ignored or dealt lightly with such problems as long-range capital planning, preparation of the annual capital budget, accounting procedures, organization of the budgeting and estimating staffs, and post-completion audits of actual results, to name a few. Within its defined scope, the conclusions of this paper may be summarized briefly:

1. Project appraisal should utilize some method of combining project data that considers the effects of time and timing explicitly, i.e., a method that embodies the procedure of discounting cash flows to a present worth at a common reference point.
2. Standards of project acceptibility should be based on some estimate of the company's long-run average cost of obtaining investment funds, adjusted upwards in periods

during which the amount of funds available is inadequate to finance all projects that meet the company's long-run minimum acceptance standards.

Although space limitations prevent even a cursory examination of the kinds of data that should be entered into the stream of cash flows, the basic principles can be stated briefly in a single sentence. The data used for project appraisal should be in the form of incremental cash flows for each year of the project's estimated life, after allowance for income taxes, using as a bench mark an acceptable alternative requiring less investment than the proposal under review.

The practical problems of applying these methods and obtaining the necessary data are not insignificant, but these problems must be solved in any soundly conceived system of capital appraisal and rationing. Without information of the sort suggested in this paper, management must necessarily lack an adequate quantitative foundation on which to base its capital expenditure decisions.

* * *

BUSINESS INVESTMENT POLICY *

A Critical Review

While this latest work by George Terborgh carries a much broader title than his well-known "Dynamic Equipment Policy", its scope is fundamentally the same. It deals primarily with a methodology for equipment replacement analysis, carrying forward and refining some of the ideas that were introduced in the earlier work. It is written in the same easy style, pointedly illustrated with examples, and contains many pragmatic admonitions for the practitioners. Other writers on the subject might well follow Terborgh in stressing the post-audit as an essential feature of the practical methodology. However, despite the inclusion of a chapter on Problems of Investment Policy, it has little to do with this subject. Too many matters of major importance in investment policy formulation are touched only obliquely, or not at all, in the discussion. The treatment of obsolescence and deterioration is a case in point.

Obsolescence and deterioration are computed in the MAPI system with respect to fixed functions. This is a considerable simplification of a multidimensional problem. Obsolescence may in some instances be brought about simply by a change in "mission", to use the military term, or function. It is perhaps because of the reviewer's experience in military operations research, where

* GEORGE TERBORGH: Machinery and Allied Products Institute and Council for Technological Advancement, 1200 Eighteenth Street, N.W., Washington, D.C., 1958. 260 pp. $6 (A MAPI Study and Manual)

considerable effort has been expended in the study of obsolescence problems, that the omission of this dimension seems conspicuous. However, this form of obsolescence is also important in business investment planning and policy making. Terborgh comes into oblique contact with the concept in a three-paragraph qualitative discussion on "Functional Downgrading" (pp. 70-71), which is at least a cousin of the general problem. This is perhaps a sufficient view of obsolescence for the purposes of MAPI methodology. It may be a reasonably complete definition of the obsolescence problem as seen by many machine tool manufacturers whose efforts are directed to the development of improved machines for performing fixed functions.

It may appear to be a sufficient concept of obsolescence for businesses such as independent iron foundries, screw-machine products plants, gear works, and other specialized suppliers to end-item industries. Still, a manufacturer of cut gears might wish he'd paid more attention to process obsolescence if several years after purchasing new small-gear cutting capacity, he found the load factor dropping through loss of markets to molded nylon gears.

For many end-product and service businesses the fixed-function, and even the functional downgrading, concept of obsolescence is entirely too narrow to support an adequate investment policy. Investment policy makers in the automobile industry are much concerned, we suspect, with the possible <u>process</u> obsolescence of much of their captive iron foundry capacity through a change in requirements from cast iron to aluminum alloy

engine blocks. Facing such risks, top management may, by policy decision, establish a high cutoff rate (MAPI terminology for required next-year rate of return on a proposed project) for new investment in the divisions subject to these risks.

When we speak of "risks" we are actually referring to uncertainty. A firm's investment policy is its strategy for the management of resources in the face of uncertainty. The uncertainty "dimension" of the policy problem is not eliminated by ignoring it. Terborgh ignores it. This is not to say that he denies it, but merely that he has nothing helpful to say about how it may be treated. The explicit methodology of the MAPI system itself is deterministic, and is explained in terms of deterministic inputs. Terborgh does not explain what the MAPI system technician is to do if the "front office" supplies him with an estimated next-year plant operation rate in the form of a probability distribution.

Another major problem in investment planning is "lead time", or "break-in" period. This effect is neglected in the MAPI Formula Earnings Projections (Chart 2, p. 72) which show earnings beginning at a maximum at time zero and continuously declining thereafter. This unrealism is unimportant in cases such as the replacement of a milling machine with an improved machine of the same general type. Moreover there are definite procedural advantages to be gained by including the effect in installed cost estimates, as Terborgh suggests. But what of problems involving lead times of a year or more?

In our opinion the MAPI concepts are too narrowly specialized to be of any value in such problems. Terborgh appears to think

otherwise, but his discussion (pp. 132-133) comprises only two paragraphs of superficial remarks on the problem, including the suggestion that "A crude approximative adjustment is to compute the after-tax 'performance deficit' for the break-in period and add it to the cost of the project" (omitting interest considerations). In general, long lead-time projects tend to involve large investments. They are frequently concerned with process obsolescence, and in some instances have crucial significance for survival of the enterprise. They are invariably complex and involve factors not contemplated in the MAPI system. (For example, the "urgency" of an air line operator's conversion to jet passenger aircraft is heavily influenced by estimates of competitor's plans.) We cannot regard seriously the author's implied suggestion that such problems can be satisfactorily handled by "a crude approximative adjustment" on what is basically a replacement analysis methodology. Moreover, we consider it a weakness of this work that the author does not explore the limitations that are imposed on the MAPI system by its concepts and its unidimensional criterion function.

Criterion functions are the practical devices that we employ to quantify the multidimensional property variously referred to as "value", "worth", or "utility". We can only conjecture that a function relating <u>all</u> the dimensions is implicit in the final management decision process. As analysts in direct support of top management we may be able to deal explicitly with <u>several</u> dimensions. In equipment replacement analysis, however, we generally accept the simplification afforded by a unidimensional

criterion function, e.g., payoff period, the MAPI "next-year return on investment", and so forth. We have some confidence from experience that "satisfactory" results can be obtained with such criterion functions providing they are (1) appropriate to the problem, and (2) compatible with higher level objectives (i.e., investment policy).

The "universal" criterion function along with the universal fact-finding method and the universal mathematical model constitute the three fundamental unattainables, but for which such professional activities as Industrial Engineering and Operations Research would be clerical occupations. In some studies on air defense problems we found that at least six different criterion functions were in current use; and in our own analyses we found use for three of them. Even in such a relatively limited area as equipment replacement analysis the practitioner should, in our opinion, be prepared to choose among a minimum of three or four criterion functions with which he is thoroughly familiar. In earlier remarks on process obsolescence we suggested that management might demand a high "next-year rate of return" on proposed equipment replacements within the threatened process. Actually, the use of payoff period in such a situation might provide a better basis for management consideration.

It is true, of course, that any factor can be brought into consideration, no matter what the criterion function and methodology, as part of the "intangible" analysis. Thus, Terborgh suggests (p. 202):

"down-rank projects that absorb intangible assets from

> the rest of the business, as compared with projects that do not . . . the merit of a proposal must be judged by its net benefit to the business as a whole, not by its separate results."

Such cognitive remarks are useful admonitions to the practitioner but leave some important things unsaid about the "intangibility" problem. "Intangible assets, costs, and benefits" are the salvational concepts of economic analysis which provide a repository for whatever cannot be explicitly treated under a particular criterion function and set of methodological assumptions (including the assumptions implicit in the methodology together with those that are required in order to implement it). "Intangibility" is therefore a relative property. A problem is "tangible" or "intangible" according to whether it can be handled by means of the particular conceptual tools one has chosen, or has been constrained, to employ.

Examples in the area of replacement analysis are not difficult to find. Using the MAPI system to evaluate Project "A" against Project "B", with a fixed estimate of the operating rate, "A" might show a higher next-year return on investment while "B" offered the "intangible" advantage of lower fixed costs. This factor could become more tangible under a present worth comparison treating the operating rate as a distributed variable. Thus even in the limited area of engineering economics which comprises replacement analyses on fixed functions we are inclined to prefer a "kit" of criterion functions and techniques as against the adoption of any one "system". We believe, in other words, that the direction of engineering economic studies is a task for well-informed professionals, not for "formula" specialists.

Indeed, Terborgh's Chapter 3 (Popular Rule-of-Thumb Tests of Investment Merit) is an excellent sermon on sins of the formula specialists. However, he seems to have a rather strong opinion that all these difficulties are attributable to the concepts themselves, which he refers to repeatedly as "blind guides". Though we agree with his cataloguing of symptoms we think his diagnosis is wrong. We believe, as suggested above, that it is the analyst who provides guidance for management on investment alternatives through the use of concepts and methodologies. Without judicious selection and employment by the analyst we should not expect anything but "blind guidance". What is surprising to us, however, is the suggestion that the MAPI system has some sort of built-in illumination that no other methodology possesses. The suggestion is strongly made in a number of places, including, for example, the first sentence of Chapter 4 (p. 39): "Having paid our respects to the popular rule-of-thumb tests of investment merit, we can now get down to the main business of this manual, the MAPI analytical system." And again in the concluding Summary (p.210):

> "What we claim for the MAPI system, essentially, is this. It is rationally contrived to carry out a clearly stated purpose: the ranking of projects in the order of urgency. It rests on simplifying assumptions that are also clearly stated . . . You can proceed deliberately, and with your eyes open, from a recognized point of departure. We submit that this is better, on any count, than floundering around in the dark."

The author surely is aware that some excellent analyses were made in the practice of engineering economics prior to the MAPI revelations, so that we may construe the latter part of this statement as an expression of enthusiasm for the MAPI system rather

than a considered judgment on the prior history of the field. This in itself will invite a cautious approach to the MAPI system by experienced engineering economists who have gained success only by learning to trace a path carefully in the twilight zone between guess and analysis. Particularly to be distrusted is the sudden burst of light which comes, so to speak, from artificial stimulation of the optic nerve rather than genuine illumination of the problem.

We would rephrase the suggestion that the analyst "can proceed . . . with . . . eyes open" to an admonition that he had <u>better</u> proceed with eyes open, and that he should in particular ignore the invitation in the beginning of Chapter 4 to take MAPI theory on faith:

> "The theory of investment analysis is not easy (witness the profusion of fallacies in common acceptance), and we have no intention of going into it any further than necessary. Nevertheless, the discussion will occupy this and the three following chapters. As we indicated earlier, a study of this material is essential to a full understanding of the MAPI system, but it is not absolutely essential to its practical application. If you are willing to take the theory on faith, you can skip at once to Part III."

We would suggest that these four chapters are imperative for the analyst who intends to apply the MAPI system, for it is here that one will learn just how much the designers of the MAPI system have been willing to take "on faith". Briefly, the MAPI system employs five estimated "factors": net investment, operating advantage, capital consumption avoided, capital consumption incurred, and income-tax adjustment. While the MAPI system prescribes a special form for aggregating the component estimates

that comprise these factors, there is nothing unique about the procedures employed for obtaining the estimates for the net investment, operating advantage, and capital consumption avoided factors. The greatest novelty of the system rests in the determination of "capital consumption incurred". (One should note that while the consumption-of-capital notion underlies "capital recovery", this concept can not be equated to the MAPI "capital consumption".) In so far as the capital consumption concept is concerned, Terborgh's discussion is excellent. However, as Terborgh says, implementation of the concept "is a real headache". The MAPI prescription for this headache is a liberal dose of assumptions bearing no necessary resemblance to reality.

The development begins with postulates concerning a decline in earnings through deterioration and obsolescence (i.e., the appearance of superior alternatives in the future). Qualitatively the supposition of such a decline is a reasonable and useful concept (subject to the "lead time" phenomenon noted earlier). However, we can find only a rhetorical foundation for the quantitative estimates through which the concept is implemented (p.69):

> "So far as the decline in earnings is due to obsolescence, we can speak with some assurance. While the impact of this factor is 'lumpy' in individual cases, there is no reason to believe that in general, or in terms of averages, it is more likely to occur at one stage rather than another in the service life of an asset. Over-all, it probably represents a fairly steady and continuous accumulation. From the standpoint of probability, therefore, the most reasonable assumption is that it is spread indeterminately over time, hence that its incidence is random.
>
> "When we are dealing with occurrences spaced in random fashion over time, the best assumption we can

> make is that they will occur at a uniform rate. It is reasonable to suppose, therefore, that insofar as the decline in operating earnings with age is attributable to the effect of obsolescence, it will proceed in this fashion."

The MAPI system designers are mistaken if they assume, as it appears in the quoted passage, that the presence of "randomness" (indeterminacy) defines the nature of a decay function. It is well-known, for example, that radioactivity decays exponentially, though the emission of a particle is a "random" occurrence.

It appears to us that the reasonableness of a supposed pattern of decline would be most convincingly established by observational data. Since Terborgh cites no data we are left with the presumption that MAPI research on this problem has, thus far, been confined to speculative theory. Some confirmation for this view is suggested by the fact that the theory also includes two other decay patterns, one with a positive second derivative, the other with negative. Qualitatively there are no other possibilities for a continuously declining function; the second derivatives must be positive, negative, or zero. Terborgh remarks (p. 71): "While it [the uniform decline] is probably as good a universal, or all-purpose, projection as can be made, there is no reason why the analyst should not be offered a choice." But if there is no reason for restricting the choice one might as well acknowledge that there was no particularly cogent reason for choosing uniform decline in the first place.

Since the MAPI approach to capital consumption begins from a conjectural representation of deterioration and obsolescence effects, the final MAPI "Chart Allowances" are also conjectural.

We think that prospective users of the MAPI system should be clearly aware of this, and of several other features of the "Chart Allowance" computations. One should note that the MAPI system uniformly assumes a 25/75 ratio of debt to equity financing of projects and then applies a debt interest rate of 3% to a pro-rata portion of the future services in discounting them to a present worth. The MAPI system designers apparently assume that the risks of the project that produces the future services are dependent upon the method of financing. They seem to equate entrepreneurial risks to those of creditors with liens against assets. Be this as it may, in MAPI rationale the higher the debt/equity capital ratio the greater the present worth of any given set of future values. There is, we think, an alternate view which sees the risks for equity capital tending to increase with the debt ratio. While this feature of the MAPI rationale may be acceptable to some, we believe others will find it incompatible with their established investment policy.

One need not accept this rationale, however, for it is possible to construct one's own "Allowance Charts" according to other conditions but following the general approach outlined by Terborgh. We would, in fact, recommend that <u>all</u> users of the MAPI system construct their own allowance charts so as to show capital consumption <u>only</u>. The MAPI charts combine this estimate with an estimated tax saving from first-year deductions (although they have no direct functional connection). In our opinion this maneuver belies the "deliberate-proceeding-with-eyes-open" claim that Terborgh makes for the system in his final chapter. He

describes this feature of the system more realistically when he refers to the chart allowance (p. 109) as the "mystery item of the form". Indeed it is. The amount of capital consumption actually charged against a project will be a complete mystery to the analyst who accepts the author's invitation to neglect the chapters on theory and simply follows the application instructions provided in Part III. Even after a careful study of the discussion on theory he will find it somewhat tedious to extract capital consumption from the MAPI charts. It seems strange that the factor which is most heavily stressed in the discussion on theory should be made so obscure in the application procedures.

This feature of the MAPI system is no less an "exercise in mysticism" than some of the practices which Terborgh condemns in other systems. It appears to us after careful examination that it has even trapped the designers of the system, and the author of Chapter 14 (Illustrative Cases), into a fundamental inconsistency. To develop our analysis we first call attention to the MAPI assumption (p. 198):

> " . . that new investment has the same 'mix' of debt and equity capital as the existing investment of the company."*

As its "standard condition" the MAPI system employs a 25/75 debt to equity capital ratio. Accordingly, the MAPI "Chart Allowances" include a first-year tax "saving" due to the deduction of interest

* This assumption and the associated rationalization for choice of an interest rate on debt financing are not cogently argued, in our opinion. We accept them in this discussion simply as a specification of the MAPI system.

expense incurred in debt-financing of 25% of the net investment required by the project. But,and here is the fundamental inconsistency, while crediting the project with tax "savings" due to deductible interest expense the MAPI system fails to charge the project with the expense which gives rise to the deduction.*

It is possible that the MAPI system designers believed they were including debt interest expense through the employment of a debt interest calculation in the estimation of capital consumption. That this is not the case is clear from a study of Appendix C. It is even more clear that one cannot logically claim tax deduction "savings" for a project expense item without charging the expense against the project. It is also clear that the MAPI assumption on debt-equity financing does logically require an interest expense charge.

* There is no specific provision for debt interest expense in the MAPI form. The instructions on application of the MAPI system fail to mention it. And most significantly, all of the ten illustrative cases in Chapter 14 omit debt interest expense although they include the "tax saving" due to deductible debt interest in the chart allowance. It is interesting to observe that the distortion in study results due to this error is in many instances more significant than the variation that would have been introduced had one used straight-line depreciation instead of the MAPI capital consumption estimates which Terborgh considers so vastly superior, and so "crucially important" (p. 64). In actuality, we believe that Terborgh exaggerates the relative importance of this estimate relative to other estimates that enter into the final study result. We note that in two of the ten illustrative cases in Chapter 14 the operating advantage "assigned" to "Flexibility" is greater in magnitude than the "Chart Allowance". Thus there is no point in attempting to get appreciably greater precision in the latter estimates than one achieves in the former. We cannot tell from the text that the values "assigned" to flexibility were other than off-the-cuff estimates. Thus, in so far as many practical situations are concerned, we are inclined to regard the championing of one particular device as against another means of estimating consumption of capital as a somewhat quixotic enterprise.

Perhaps the MAPI system designers were victimized by that ancient form of mysticism which consists in doing a simple thing in a complicated way. According to the MAPI assumption 25% of "net investment required" (Line 5 of the MAPI "Form") is debt financing. Thus, it is only necessary to include in part 2 of the form an additional line for interest expense which is computed: Line 5 x 25% x debt interest rate. This puts the interest expense item in the "Next-year Advantage from Project" category where it belongs. The tax "saving" will then be included automatically in the computation of "next-year advantage after income tax". This procedure should have made it nearly impossible to claim the "saving" without charging the expense.

SUMMARY

Before summarizing our predominantly adverse criticisms a remark is in order on the one aspect of Terborgh's work which impresses us as particularly meritorious. His observations on practical problems of replacement analysis are developed in an exceptionally effective style and are appropriate to the field at large, not merely to MAPI system practitioners.

But in its principle subject matter - replacement analysis methodology - we find the work disappointing. The author strolls through his subject with a telescope instead of sitting down to it with a microscope and dissecting tools. Through one end of his "research instrument" the MAPI system appears greatly magnified; through the obverse end all other systems are diminished. The fundamental contributions which seem to be promised by his dismissal of "popular rules-of-thumb" never quite

materialize. Facile phrases invite the reader to slip over the equivocal issues. The fundamentally sound concept of "capital consumption" is quantified by a rule-of-thumb, whereupon the thumb itself is lost in the obscurity of the MAPI "Chart Allowance" procedure.

For all this we think many will read the work and find stimulation in it, for Terborgh is by no means unimaginative. At the same time we doubt that many will be persuaded to seek salvation through the MAPI system, except perhaps some who may believe that formulas are more important that analysts in generating investment priority rankings.

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A REVIEW OF SELECTED ENGINEERING ECONOMY ARTICLES APPEARING IN THE McGRAW-HILL "PLAN '59" SERIES

In the autumn of 1958, McGraw-Hill Publishing Company put increased emphasis on various factors to be considered in proposed industrial modernization programs. This was done in a "Plan '59" series of articles highlighted in their many business and trade journals, e.g., Business Week (September 27, 1958), Factory (November 1958), Control Engineering (December 1958), Electronics (October 24, 1958), Engineering and Mining Journal (November 1958), Petroleum Week (November 7, 1958), Power (October 1958), Product Engineering (October 13, 1958).

The series was in general a very valuable one, pointing up the economic, financial, and technical problems that must be faced by management. The degree of emphasis on these three factors varied with the specific interests of the readers of the different journals. But all of the journals stressed the importance of the engineering economy decision-making function as related to proposed capital plant and equipment expenditures.

Only the first three of the journals listed above, covering a range of industries, analytical abilities, and levels of economic and technical sophistication, will be reviewed in this paper.

One of the better analyses of the considerations involved and calculations required in economy decisions was the one appearing in Business Week. In it, the editors look principally at:

1. Some of the dangers inherent in putting much faith in such rules of thumb as "payout period" (ratio of first cost to

annual savings after taxes) or so-called "rate of return" (ratio of annual savings after taxes to first cost, in percent). The latter is actually the rate of return of investment rather than rate of return on investment, the meaning normally (and properly) assigned to the term "rate of return".

2. Joel Dean's Discounted Cash Flow method of analysis. A simplified cash flow table is used to illustrate the calculations involved in the comparison of a hypothetical new machine and an existing machine. The example finds, from determining that discount rate which makes the present worth of the change in cash flow after income taxes equal to zero, that the rate of return on investment is 23%.

3. George Terborgh's MAPI approach, as refined and expanded recently in his "Business Investment Policy" (Machinery and Applied Products Institute, 1958). The same example is carried through, yielding a "rate of return" of 22%.

It is interesting to note that these two methods, so different in basic formulation, yield similar results (23% and 22%). However, the inherent flexibility of the Discounted Cash Flow method allowed it to be adjusted to approximate the more rigid assumptions of the MAPI method. For example, the MAPI method has built into its basic formulation a compensation for the effect of future technological improvements. This compensation effectively reduces the estimated annual savings of the proposed new equipment by a constant amount each successive year over the life of the equipment. The Discounted Cash Flow method then reduced its estimated annual savings from the proposed new equipment by a similar amount each

year, so as to yield similar results. But requiring the Discounted Cash Flow method to conform to the rigid assumptions of the MAPI method forces a compatibility between the two methods where in general none exists.

Yet an important difference remains. The MAPI system includes in its formulation the assumption that the company's capitalization is made up of one-fourth long term debt, bearing 3% interest, and three-fourths equity capital, with a minimum attractive rate of return after taxes of 10%. Superimposed on these is the so-called "rate of return" result. Had the article used MAPI's own term, "MAPI Urgency Rating", however, it would have been more precise. The result of the MAPI analysis is not rate of return on investment in the usual sense, but rather a measurement of the benefit of having the project now as against deferring it for one year.

If one is willing to make the assumptions inherent in either system, each will produce a relative ranking of proposed projects in order of their "economic priority". But these ranking factors are not in general compatible between the two systems, as the article attempts to show them to be.

One statement in the article tends to be misleading. It is to the effect that one may calculate the payout period directly from the rate of return. In the above example, the 22% or 23% supposedly results in a payout period of "about four years", presumably from taking the reciprocal of the rate of return in decimal form. This is true for very long lives, but one would have a substantial error in the case of economic lives of less than ten years.

The methodology[1] behind the Discounted Cash Flow technique is of course not original with Joel Dean. It has been progressively developed since the turn of the century, and used in one form or another by many economic and financial analysts. So it is not surprising to find that the basic methodology has acquired several different titles. Principal among the titles presently in use are Discounted Cash Flow, "Investor's Method", and "Rate of Return". Business Week preferred the first of these, and Factory preferred the second. The writer of this review prefers the third, Rate of Return, and will use this term consistently throughout the remainder of the review. Rate of Return is the oldest and most widely used term, and is more descriptive of a method which may use compounding as well as discounting to arrive at a rate of return result. All three of the above titles are meaningful, however.

An interesting article appeared in Factory (November 1958), explaining five methods of computing rate of return. These methods are the same ones discussed in the above Business Week article, with the addition of the "Annual Cost Method".

The treatment of the MAPI method and the Rate of Return method fairly reflect their application to practical problems. As before, however, the writers of this article attempt to force a compatibility between these two primary methods which in general does not exist. Although it is interesting to observe how the Rate of

[1] In general, finding that interest rate which will make the present worth of the investment's change in cash flow after taxes equal to zero. For a clear, complete explanation of this methodology, see Eugene L. Grant's "Principles of Engineering Economy", 3rd edition, Ronald Press, 1950.

Return method's data would have to look to yield a rate of return equal to the MAPI Urgency Rating, it is misleading thus to indicate that in general they give the same results.

Factory's discussion of the Annual Cost Method treats income tax and cost of capital recovery in a manner that may be of interest to analysts in a regulated public utility, but is of no interest to those in private competitive industry and will only serve to confuse this latter group (which make up the majority of Factory's readers). Further confusion stems from the author's attempt to force some sort of "rate of return" index out of the Annual Cost results, apparently to show compatibility with the Rate of Return and MAPI methods. The result is essentially a rate of return (assuming <u>infinite</u> life) over and above the cost of capital recovery at 8% and is thus not even an adequate ranking factor.

The Factory article, with a few exceptions, fairly states the advantages and disadvantages of the five systems it discusses and illustrates. Notable among these exceptions is the statement to the effect that the Rate of Return method presents difficulties in projecting for many years in advance the expected receipts and disbursements. But this is not a disadvantage; the opportunity to be able to do this is an advantage. If one does not so project, it will be done for him, possibly with gross errors, by the built-in assumptions of the other systems discussed.

An additional fallacy in the author's discussion of Rate of Return was his statement to the effect that the results of this method, since they are inconsistent with standard accounting

practice, will be misleading. However, the books of account will be consistent with the properly estimated cash flow of the investment, time adjusted. Moreover, in engineering economy analyses, it is the books of account which are misleading since they do not recognize (in fact, cannot recognize) the time value of money. But any analyst worthy of the title should have no difficulty reconciling this difference.

One of the poorer surveys of engineering economy methods was that presented in Control Engineering (December 1958).

The author presents a series of simple ratios (e.g., annual savings to annual cost, annual savings less depreciation to depreciation, etc.), which he calls "economic decision-making techniques", with no discussion of the misallocation of investment funds which could result from their use. He also discusses briefly the MAPI method (1949 version) using the old terminology, without mentioning the rigid assumptions that are necessary in its use.

All of this is done with no attempt at comparison of one method with another, or a recommendation as to which is best. Perhaps it is just as well; none of the techniques are of much value to an economy analyst.

Perhaps a criticism that could be made about this whole McGraw-Hill series of articles in the several journals is that they attempted to cover the whole field of available economy methods. Had the several authors attempted to discuss only one or two of the better techniques available (e.g., MAPI and/or Rate of Return) and ignored the poorer techniques, a better job of analysis could have been done within the journal space made available. Indeed, had the

several authors pooled their thinking and come up with just one capital equipment economy article for all of the McGraw-Hill journals (or, if mutual agreement could not be reached, request one from a group like Joel Dean Associates), the result would have been far better than the several scattered attempts.

Granted there are differences in the level of financial sophistication between the readers of the several journals. But this could be compensated for perhaps by varying the graphic presentations and explanation of terms appropriately, rather than varying the fundamental analytical techniques. As it was, the casual reader may very well have become confused by the many minor differences of opinion among the several journal writers as to acceptable techniques and terminology.

But it is a very healthy thing that the financial and engineering economy problems which occur in a modernization program were given the strong emphasis in the "Plan '59" series that they were. Articles like the excellent Business Week one are sure to assist the industrial engineering economy analyst in making more realistic quantitative analyses and qualitative judgments when considering proposed capital plant and equipment investments.

David A. Thompson

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BACK ISSUES
of
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We receive increasingly frequent requests for back issues of The Engineering Economist, from subscribers who wish to complete their editions. Unfortunately, all of our remainders on many of these issues have been sold. In an effort to obtain some of these copies for our subscribers, we are again offering to buy back a limited number of copies, especially of Volume 3, at fifty cents each plus second class mailing cost. Please do not send copies before letting us know what copies you would like to sell, using the coupon below:

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Review

HOW TO EVALUATE NEW CAPITAL INVESTMENTS *

Although this article breaks no significant new ground, it is a valuable addition to the literature of engineering economy. The author, a vice president of Continental Oil, describes the evolution of his company's approach to evaluating investment proposals. In so doing he indicates why Continental switched from the payout method to discounted cash flow; moreover, he gives some very interesting illustrations of how the latter is used. The inclusion of several charts and numerical examples helps to make Mr. McLean's work an especially lucid introduction to the practical use of discounted cash flow.[1]

After thorough study of the matter the management of Continental Oil Company decided to stop using the payout period as a means of evaluating investment decisions. They felt the need for a more refined method of comparing alternatives. Their dissatisfaction with payout stemmed from the fact that it fails to recognize differences among alternatives after the intial investment has been recovered. It was determined that some type of rate of return measure ought to be used, and discounted cash flow was chosen over several approximate methods for the following reasons:

* JOHN G. McLEAN: Harvard Business Review, Vol. XXXVI, No. 6, pp. 59-69, November-December 1958.

[1] Also known as the "investor's method", it consists of finding a rate of return that makes the present worth of estimated future income (cash receipts less cash disbursements) equal to the investment.

1. It gives a true rather than an approximate rate of return.

2. It generates figures that are comparable to financial rates of return, e.g., bond interest.

3. It allows for differences in the time patterns of income from investments.

The last point is especially important in the oil industry. Income from producing oil wells tends to decrease with time, whereas the income from a service station will likely increase during its early life and then level off.

Solutions for problems involving several types of income patterns are given. These provide a clear idea of the company's technique, including some time-saving short cuts. Mr. McLean mentions the use of a 10% "bench mark" minimum rate of return figure for projects involving low risk, such as marketing investments. He also states that this figure is modified for higher risk investments. A discussion of the way in which these higher rates are set would have been an interesting addition to the article.

In concluding, the author expresses general satisfaction with discounted cash flow as a means of evaluating investments. He states that the problems involved in introducing this method to company personnel were much less substantial than expected and that the calculations which are required have not been troublesome. The only problem of any importance which Continental Oil has not been able to solve is that of determining actual departmental return-on-investment figures. Such quantities would provide a valuable basis of comparison for rate of return figures

that are calculated for proposed projects; but neither return on initial investment in plant nor on investment in depreciated plant is comparable to the return on investment found by using discounted cash flow.

David V. Heebink

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SUMMER SYMPOSIUM
The Engineering Economy Division
American Society for Engineering Education
and
The Engineering Economy Research Committee
American Institute of Industrial Engineers
HOTEL WEBSTER HALL
Pittsburgh, Pennsylvania
June 13-14th, 1959

SATURDAY, JUNE 13th

8:00 a.m. - 9:00 a.m. REGISTRATION

9:00 a.m. - 12:00 noon CAPITAL BUDGETING AND PROJECT JUSTIFICATION

Chairman: Lt. Col. J.C. Hempstead, U.S.A.F. Academy
Panel: "Project Justification"
George Terborgh, Machinery and Allied Products Institute
"Capital Budgeting for Manufacturing"
V.J. Reilly, General Electric Company
Discussant: Diran G. Bodenhorn, University of Chicago

2:00 p.m. - 5:00 p.m. POST AUDITING

Chairman: Raymond R. Mayer, Illinois Institute of Technology
Panel: "Procedures for Comparing Actual with Expected Economies from Equipment Replacement"
Frank H. Zoeller, Allis Chalmers Manufacturing Co.
"An Approach to the Determination of Realized Benefits from Capital Investment"
Richard P. Connelly, A.O. Smith Corporation
Discussant: Gerald J. Matchett, Illinois Institute of Technology

7:30 p.m. - 9:00 p.m. ESTIMATION OF WORKING CAPITAL REQUIREMENTS FOR LONG-RANGE PLANNING

Chairman: Ernest H. Weinwurm, De Paul University
Speaker: James B. Weaver, Atlas Powder Company
Discussant: Colin Park, Haskins & Sells

SUNDAY, JUNE 14th

9:00 a.m. - 12:00 noon EFFECTS OF TAXES ON INVESTMENT DECISIONS

Chairman: Robert M. Eastman, University of Missouri
Panel: "Tax Problems Arising from Capital Investment in a Large Utility"
William J. Murphy, Consolidated Edison Company
"Tax Effects in an Industry with Rapid Technological Change"
Paul W. Smith, Union Carbide & Chemicals Corp.
Discussant: Eugene L. Grant, Stanford University

2:00 p.m. - 5:00 p.m. EVALUATING UNCERTAINTY

Chairman: Billy E. Goetz, Massachusetts Institute of Technology
Panel: "Method of Dealing with Uncertainty in the Environment of the Firm"
Richard B. Maffei, Massachusetts Institute of Technology
"The Valuation of Uncertainties in Inventory Control"
Robert B. Fetter, Yale University
Discussant: Loring G. Mitten, Northwestern University

7:30 p.m. - 9:00 p.m. EVENING SMOKER Informal Discussion of Research Needs in Engineering Economy -- And How to Meet Them

Chairman: R.O. Swalm, Syracuse University

REGISTER NOW

Non-Members Welcome
Write to: M. K. Smith
American Telephone & Telegraph Co.
195 Broadway
New York, New York

At University of Pittsburgh and Carnegie Institute of Technology
REGULAR MEETING OF ENGINEERING ECONOMY DIVISION
June 15th, 1959
Non-Members (ASEE) Welcome

MORNING SESSION
"Decision Making for Capital Investment -- American and Soviet Practice"

Chairman: William T. Morris, Ohio State University
Discussant: John E. Ullmann, Stevens Institute of Technology

AFTERNOON SESSION
"New Approaches to Teaching Engineering Economy"

Chairman: Arthur Lesser, Jr., Stevens Institute of Technology
Panel: "Teaching the Subtle Art of Data Collection"
Billy E. Goetz, Massachusetts Institute of Technology
"Relating Engineering Economy to Fiscal Management"
David V. Heebink, Stanford University
"A Rate of Return Approach to Engineering Economy"
William D. McIlvaine, The Rand Corporation

(See ASEE Program for Further Information)

REVISION OF BULLETIN F

There has been much discussion in recent years concerning possible revision of accepted guidance material for estimating normal usable lives of industrial buildings and industrial equipment.

Our readers will be interested to know that the Treasury Department does not intend to make such a revision. Fred C. Scribner, Under Secretary of the Treasury, has kindly given us permission to publish an excerpt from his presentation at the Ninth Annual Midyear Conference Banquet of the Tax Executives Institute (Washington, D.C., February 16, 1959). The excerpt appears below.

The Editor

"It had been strongly suggested to me that it might be well not to discuss tonight, depreciation or the present status of Bulletin F. There was a fear, born of experience in other cases, that this area is so complex, has such an important legislative history and is of such intense interest that any brief statement would create more problems than it would settle. Such advice may prove to have been correct.

"I am taking up the subject, however, because this is a field of great interest to all of you and to all of us in the Service. Here, as elsewhere, we are attempting to enforce the tax laws in accordance with the will of Congress, and in such manner, within Congressional direction, as to collect taxes with a minimum of repressive effect on the Nation's taxpayers and their activities. There have been so many questions asked about the date of issuance of a revised Bulletin F that it has seemed advisable to make a statement concerning depreciation and the present status of a possible revision of Bulletin F.

"Let's begin with fundamentals. Section 167 of the 1954 Code sets forth the general rule. It provides:

> 'There shall be allowed as a depreciation deduction a reasonable allowance for the exhaustion, wear and tear (including a reasonable allowance for obsolescence) --
>
> (1) of property used in the trade or business, or
>
> (2) of property held for the production of income.'

"This is not a new section. It has appeared in this or similar form in the Internal Revenue Code since 1918. Questions arise, of course, as to what is 'reasonable' and how best to determine the amount properly to be allowed for obsolescence.

"The general rule enforced by the Service, and it has been the rule for many years, is to allow depreciation based on the actual period of time that the item of machinery in question is used in trade or business by the taxpayer. In other words, the taxpayer by usage determines the period over which an item is to be depreciated.

"In order to provide some guidance to Revenue Agents as to the normal usable life of a particular piece of property, and in order, as well, to assist taxpayers desiring information as to what might be considered a normal life for depreciation purposes, the Treasury Department issued Bulletin F some seventeen years ago (January 1942).

"I wish to emphasize that, subject only to fundamental requirements of consistency and reasonableness, this was intended only as a guide. It was not the intent at the time of its issuance, nor is it the intent today, that the lives set forth in Bulletin F represent the minimum life in every case. Actual usage by the

property owner is the controlling determination. It is recognized that some Revenue Agents have taken Bulletin F as the last word insofar as they are concerned. This attitude the Service has attempted and is continuing to attempt to correct. It is not the policy of the Revenue Service to substitute Bulletin F lives for the lives determined by the actual experience of the property owner.

"A practice of charging off an item of equipment over a relatively short period of time, and at the end of the charge-off period disposing of the item at a relatively substantial gain has grown up in many sections of industry. Some taxpayers, ignoring salvage value and claiming to rely on section 1231 of the Code, treat this gain as a long-term capital gain. It has been suggested that the problems created by this practice would be met, insofar as personal property is concerned, and many taxpayers would benefit, if taxpayers were permitted to ignore salvage value but required upon sale at a profit of depreciable personal property to report the gain as ordinary income to the extent of the depreciation previously taken on the property. If such a proposal were adopted, it might well be a step in the direction of both fairness and simplification. Furthermore, it would permit more relaxation in the area of making certain that the life chosen by a taxpayer for depreciation purposes corresponds to the actual period of time during which the taxpayer intends to use and will use the item of property.

"Even if a property owner is allowed to determine by his own experience the period of time over which he will charge depreciation on a particular piece of machinery, the amount which he

recovers back through depreciation charges during such determined life may not always give him sufficient funds to buy a replacing machine, that is, a new and modern machine designed to do the work theretofore performed by the fully depreciated item. Technological developments and increased costs do mean that the replacing machine will, in many instances, cost more than the worn out item although the new machine may be more efficient and in many instances will show less cost per item.

"There are many taxpayers who would like to have a depreciation policy which would allow them not only to recover back the full cost of a machine, but would like, in addition, to recover back a sufficient amount to pay the full cost of a new, modern replacement. This approach to the depreciation problem, I am sure you will appreciate, might get us into very shaky and untenable ground. We would leave the certain and demonstrable base of original cost, and might move into the area of hypothetical and questionable appraisals of replacement cost. This approach does not seem to have the elements of a realizable program.

"Many have asked when a revised Bulletin F is to be issued. No issuance date has been agreed upon at this time, and the possibility exists that the present Bulletin may not be revised and reissued.

"Many false hopes have been raised, I believe, about what a revised Bulletin F might contain. It would be erroneous to assume that a restudy of average lives would produce many reductions apart from the obsolescence factor. The conclusion seemsplausible moreover that the obsolescence factor injects a high degree of

uncertainty into the determination of useful lives. I have the impression that large numbers of taxpayers have, on the basis of their own experience and of evidence submitted to the Agents, satisfactorily established for themselves shorter lives than a revised Bulletin F might suggest.

"There is considerable thought that a reissuance of the Bulletin in revised form might cause even more prolonged disputes than at present as to whether the normal life set forth in the Bulletin or the prospective life measured by actual usage on the part of the taxpayer, or some other form of measurement, should control the depreciation period in any particular situation. We do not believe that we would advance the resolution of the problems which do exist in the field of depreciation by reissuing Bulletin F if such reissuance resulted in agents or taxpayers assuming that the lives given in it since the Bulletin has been under intensive restudy are now to be controlling and are to over-ride the actual experience of an individual taxpayer.

"In attempting to estimate the average life of a piece of equipment, it is possible for experts in the field to come up with a reasonable estimate, although this is not at all an easy thing. Thereafter some estimate might be made of how much obsolescence could be expected in this period and some range of tolerance could perhaps be allowed to account for this uncertainty created by prospective obsolescence. However, in the technological field we are moving so rapidly and developments are coming with such frequency that these estimates might be, at best, educated guesses."

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COMMUNICATIONS

COMMENTS

On: "PROBABILISTIC CONSIDERATIONS IN EQUIPMENT REPLACEMENT STUDIES" *

By: Gordon D. Shellard
Metropolitan Life Insurance Company

(To the author, February 3, 1959)

"I have just recently read your paper on 'failure' which appeared in 'The Engineering Economist'. This topic, particularly with respect to vacuum tubes and other electronic equipment, seems to be of increasing importance. Your article should help familiarize those dealing with this kind of equipment with the very valuable method of approach you presented.

"My primary reason for writing is to suggest to you, if you are not already familiar with it, the facility of expression that adoption of standard actuarial notation gives in dealing with this problem. I am enclosing a copy of an article of mine in McCloskey and Coppinger's Volume 2 of 'Operations Research for Management' that illustrates this point. Although observations almost have to be tabulated for discrete intervals, the calculus method of presentation has advantages. Among them is the ability to focus attention on initial failures, at time 0.

"There is one point in your paper that I was not clear about. This was on page 28, where you got a standard deviation of 9.48. Was the purpose of this to find the range within which 68% or 95% of the failures would usually be? (In the normal distribution 68% of the data lie within one standard deviation on either side of the mean, and 95% within two standard deviations on either side of the mean.) But the distribution is specified by the survival function ${}_tp = .9^t$, and is far from normal. If I understand this correctly, the first formula on page 334 of my article applies here, and the proportion of tubes having failed at the end of 19 intervals is 86.5% (just before the last batch of failures, or, if m = 20, 87.8%, just after the last batch of failures) . . "

(Reply on following page)

* Salah A. Elmaghraby, The Engineering Economist, Volume 4, Number 1, Summer 1958, pp. 1-31.

REPLY TO THE PRECEDING COMMENTS

By: Salah A. Elmaghraby
Western Electric Company Engineering Research Center

(To Gordon D. Shellard, March 10, 1959)

"Thank you for the interest you have taken in my article on "Equipment Replacement", and for your comments.

"At the time the paper was written, which was about Summer 1957, I was not aware of your contribution in McCloskey and Coppinger's book. However, I am in full agreement with you on the fact that we, in the field of industrial management, can learn a great deal from the wealth of statistical knowledge already in existence in the actuarial field.

"Concerning my statement on page 28, I checked my original calculations, which are simply to determine the number m in the formula

$$\sum_{i=0}^{m} pN\,(1-p)^i = N\left[1-(1-P)^m\right] = .95\,N.$$

For a value of p = 0.1, the answer is approximately 29, and <u>not</u> 19 as printed in the paper. I am grateful to you for drawing my attention to this error."

* * *
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ANNOUNCEMENT

F. A. Gitzendanner, Chairman of the Executive Committee of the Engineering Economy Division of the American Society for Engineering Education, announces the appointment of M. K. Smith and R. O. Swalm as members of the Executive Committee, pursuant to Section 5g of the Division By-Laws, in recognition of their outstanding services.